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14. ABSTRACT

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The Musculoskeletal Readiness Screening Tool- Injury Predictor for United States Military Academy Preparatory Cadets?

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30 October 2015

DSc Doctoral Research Defense

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ABSTRACT

BACKGROUND:

Unique aspects of military service put our nation's military at increased risk for injury that may not already be captured in the FMS and other injury prediction tools. The Musculoskeletal Readiness Screening Tool (MRST) was developed to combine evidence from physical performance tests used to predict injury and tasks unique to military personnel. Tests include the weight bearing forward lunge, modified deep squat, closed kinetic chain upper extremity stability test (CKCUEST), forward step down with eyes closed, stationary tuck jump, unilateral wall sit hold, and individual perceived level of risk for injury. The Feagin hop and self-reported history of injury were added to the screen.

PURPOSE:

To examine whether MRST scores, as a composite or further broken down into individual components, were predictive of a United States Military Academy Preparatory School (USMAPS) cadet candidate sustaining a future musculoskeletal injury.

METHODS:

MRST scores were collected for 141 cadet candidates (mean age 18.63 ±1.31) at USMAPS. Injuries were tracked for the academic school year. Preparatory cadets participated in military specific training and various sports. After 9 months, mean

scores were compared between injured and uninjured groups, a ROC curve analysis, and a logistic regression model was analyzed.

RESULTS:

Seventy preparatory cadets sustained an injury. Top sports resulting in injury included football (36%) and basketball (11%) with injuries predominantly in the lower extremity including the knee (24%), hip (15%), and ankle (14%). Composite MRST scores were no different between injured (10.83) and uninjured (10.93) groups ($p=0.78$), 95% CI (-0.64, 0.85). No association observed for those with a personal concern for future injury and actual injury ($p=.13$), ($df=2$), 95% CI (-0.3, 0.04). However, there was an association between those reporting a previous injury in the previous 12 months and those incurring an injury at USMAPS ($p=.04$), ($df=1$), 95% CI (-0.3, -0.01). A score of ≤12 revealed a sensitivity of .50, specificity of .57, +LR 1.17, and –LR .89. The ROC area under the curve was .53 with 95% CI(0.44, 0.63).

CONCLUSION:

While the 6 components of the MRST were not predictive of injury in this military academy prep school population, previous injury was the only significant injury predictor.

INTRODUCTION

Musculoskeletal injuries pose the greatest threat to military readiness during both peacetime and combat operations.[8,22] Many of the musculoskeletal injuries are a direct result of participation in sports and physical training.[8] Injuries observed in military service are consistent with those incurred by professional athletes and the subsequent demands put on the military healthcare system are tremendous. In the active component of the U.S. Armed Forces, there were 3.6 million injury related encounters in 2014 alone.[5] In 2014, back pain and other musculoskeletal injuries resulted in 1.7 million medical encounters-the leading cause of medical care visits in active duty military.[5] There is a strong relationship between lost work time attributable to conditions associated with medical encounters.[5] With the financial and manpower drawdown of recent years, musculoskeletal injuries pose an increased burden on the readiness of the U.S. military.[28]

Physical training is performed regularly across the military population. For females, physical training represented the most common cause of musculoskeletal injuries.[22,33] For males, physical training closely followed basketball, football, and softball as the most often reported cause of such injuries.[22] Safety data collected from the US Air Force revealed the most common injurious events reported between 1993 and 2002 were motor vehicle-related injuries followed closely by sports-related injuries.[8] Prevention of these sports and physical training injuries is a top priority for leaders in the Department of Defense.[8]

Currently, there is an abundance of literature aimed at identifying physical and mental (actual and perceived) factors that may predict future injury. For example, prior injury, impaired strength and neuromuscular control are associated with increased risk for second injury after anterior cruciate ligament restriction in athletes.[27] However, no existing standard physical performance exam can accurately predict future injury for various athletes and occupations. As a result, sports health professionals and military clinicians treating previously injured athletes are left to use time-based protocols and expert opinion to guide their decision making process.

Injury risk is multi-factorial. A self-report survey collected on 625 females in the military revealed that the best combination of predictors of injury included those lower in rank, a history of injury, reduced weekly frequency of units runs, and increased weekly frequency of personal resistance training.[33] The strongest predictor of injury in male athletes at 12 months and 5 years was reporting previous lower extremity injury. Prior lower extremity injury was the strongest predictor of injury at 12 months for females.[18] Greater long distance training per week was a risk factor for males while previous injury was a risk factor for both males and females.[15] Previous ACL reconstruction to either knee, poor hop test symmetry, subjective knee function, and negative psychological responses were associated with the inability to return to pre-injury levels of sport.[1] There appears to be a strong positive correlation of injury occurrence with athletes undergoing greater degrees of stress, whereas athletes with increased optimism toward their activity were less likely to sustain an injury.[37] A systematic review in 2005 reported psychological factors may increase the likelihood of sport injury. [3] Also, fear of re-injury negatively influences the ability to return to play after ACL reconstructive surgery.[24] Self-confidence and psychological influences effect sport injury risk.[1,36,39]

A number of individual physical performance measures have been reported and may play a promising role in predicting future injury.[10,13,17] Further research on their predictive utility when used in isolation and in combination is needed. In the lower extremity, decreased weight bearing ankle dorsiflexion was associated with lower extremity injury.[10,11,13,17] Lack of weight-bearing dorsiflexion may impair, proprioceptive input, balance and appears to have a significant correlation with performance on the star excursion balance test.[17] Clanton et al found that four functional tests can assess whether an athlete is ready to return to play: ankle dorsiflexion lunge, the star excursion balance test, agility T-test, and the vertical jump test.[10]

Jumping, a movement routinely performed in multiple sports, requires both strength and neuromuscular control to perform without an increased risk of non-contact injury. It's postulated that hip abduction strength may play an important role in control of the knee.[19] Women demonstrate lower hip abductor peak torque and increased knee valgus peak joint displacement when landing from a vertical jump.[19] Increased knee valgus upon landing and asymmetries in landing techniques between the legs are both predictors of ACL injury.[25]

Several studies investigate the effects of faulty movement and injury prediction for the lower extremity. In 2006, active duty service members reported 743,547 musculoskeletal injuries. Injuries involving the spine and lower extremity were nearly equal at 40% and 39% of the total injuries, respectively.[16] In 2012, 83

NCAA Division I football players participated in a survey to assess low back, knee, and ankle function, in addition to performing multiple assessments of core muscle endurance. High game exposure, low trunk-flexion hold time, high Oswestry Disability Index scores, and reduced wall-sit hold time were the best combination of injury predictors.[40] Currently, there is limited research on the validity of the wall sit test, but healthcare providers can't exclude the potential for this test to help predict lower extremity and back injury without further investigation.

The lower extremity and trunk are certainly not the only areas that are susceptible to injury. Nine percent of all active duty military, non-deployed musculoskeletal injuries were in the upper extremity;[16] Sixty-three percent of these injuries in the upper extremity were in the shoulder.[16] Currently there are functional tests aimed at predicting injury in the upper quarter including, but not limited to, the upper quarter Y balance test (YBT-UQ), the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), and tests within the Functional Movement Screen (FMS™) that incorporate upper extremity evaluation. The upper quarter Y balance test can be conducted in the field setting and has been found to be a reliable test, but requires additional equipment.[6]

While individual physical performance measures have been positively associated with injury prediction, evidence also exists that a combination of functional tests can predict future injury.[9,10,23] The Functional Movement Screen (FMS™) is a tool that evaluates seven basic movement patterns to screen for likelihood of future injury. An individual composite score of less than or equal to 14 indicates a four-fold increase in lower extremity injury.[9] The FMS™ predicts injury for certain cohorts of individuals in rescue services and in the military.[7,23,29] In a recent study, firefighters performed the FMS™ and firefighter-specific testing. Two of the musculoskeletal movement variables were predictive of injury: the deep squat and push-up. FMS™ scores of <14 have resulted in a sensitivity of 0.83, a specificity of 0.62, and a positive predictive value of 85.7%.[7] A cohort of 874 Marine Corps officer candidates performed the FMS™ along with answering a questionnaire and taking a physical fitness test (PFT). Poor run-time on the PFT and poor performance on the FMS™ together combined for increased predictive validity for injury in the Marine population..[23]

However, not everyone concludes that the FMS™ accurately predicts injury. Warren et al. found that the FMS™ is a poor predictor of non-contact and overuse injuries.[38] For high school athletes, a study with a large sample size found no significant associations were found between total FMS™ scores and injury status.[2] FMS™ scores were no different for female soldiers serving in the Israel Defense Forces that incurred an injury versus those that did not.[20] Previous studies have shown that a score of 14 or less predicted future injury occurrence; this was not the case for a cohort of major junior hockey players.[12] The FMS™ also requires use of a test kit costing approximately $180. The expense combined with the burden of additional equipment makes this a less desirable measure of injury prediction in a field or deployed setting.

Although research to date to some degree supports the use of individual tests and the FMS™ to predict future injury, unique aspects of military service put our service members at increased risk for injury that may not already be captured in the

FMS™ and other injury prediction tools. For example, many military specialties perform their duties during nighttime environmental conditions. None of the measures previously identified examine effects of decremented vision while performing physical tasks. Under blindfolded conditions, landings from heights ranging from 0.2-0.8 meters result in a 10% greater ground reaction force thereby demonstrating the importance of vision to accurately time muscle activity.[34] Subjects tend to support their body weight on their trail leg when performing the step down with vision occluded thereby reducing the peak ground reaction force (GRF). Air Assault Soldiers performed two-legged drop landings with and without vision; simulated night time operation conditions changed the landing characteristics that potentially increase injury risk.[30]

Combining the evidence synthesis from physical performance tests with at least moderate predictive validity for musculoskeletal injury with a basic military task analysis, Thelen et al. developed a return to duty screening tool consisting of six specific functional movements and one subjective question. Due to reliability concerns this screening tool was subsequently modified and is referred to as the Musculoskeletal Readiness Screening Tool (MRST). The components of the MRST include the weight bearing forward lunge, the modified deep squat, the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), the forward step down with eyes closed, the stationary tuck jump, the unilateral wall sit hold, and individual perceived level of risk for musculoskeletal injury. The purpose of this study was to explore whether MRST scores, as a composite or further broken down into individual components, were predictive of a United States Military Academy

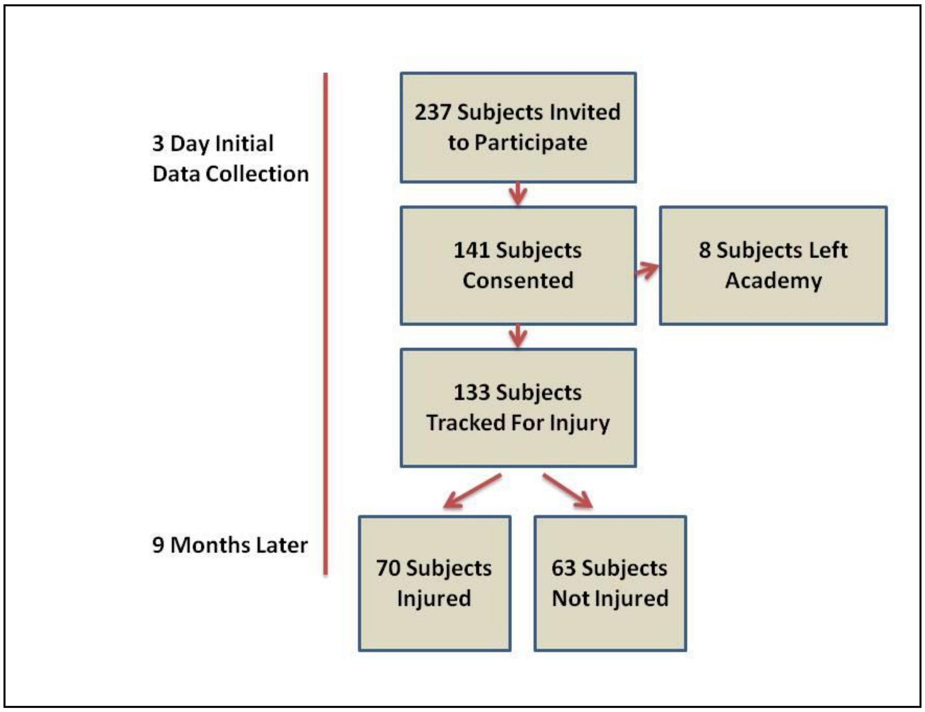
Preparatory School (USMAPS) cadet candidate sustaining a future musculoskeletal injury. We hypothesized that subjects with a lower MRST composite score would have a greater likelihood of sustaining a musculoskeletal injury.

METHODS

Study design and subjects.

This was a prospective cohort study approved by the Institutional Review Board at Keller Army Community Hospital, West Point, NY. Two hundred thirty-seven United States Military Academy Preparatory School cadet candidates were briefed during the first week of attendance regarding the study, including procedures, benefits, and risks. One hundred forty-one participants volunteered for this study (age 18 ± 1.31). Enrollment and data collection occurred over the course of three days. All investigators wore civilian clothes without rank identified to help minimize any coercion effect. Participants provided written informed consent and Health Insurance Portability and Accountability Act authorization, permitting the use of protected health information for research. After volunteering, participants proceeded directly to the health and injury history questionnaire and completed the MRST. Injury data were collected over the course of the 9 month academic school year.

Figure 1. Subject Flowchart



Musculoskeletal Readiness Screening Tool

The MRST is a screening tool composed of six functional movements. For the purposes of this study, an additional movement and two questions regarding the subject's perceived level of risk of injury and prior reported musculoskeletal injury were also reported. Collectively, the special tests are designed to briefly assess overall physical function in both the open and closed kinetic chain, as well as, self-perception regarding the possibility of a future injury. Tests are scored on a 0-2 ordinal scale and include the weight bearing forward lunge, the modified deep squat, the closed kinetic chain upper extremity stability test (CKCUEST), the forward step down with eyes closed, the stationary tuck jump, the Feagin hop, the unilateral wall sit hold, and individual perceived level of risk for musculoskeletal injury. A score of 2 indicates the subject was able to perform the movement correctly and without pain. A score of 1 indicates that only part of the movement was complete and the subject performed the movement without pain. A score of 0 indicates that the subject had pain with the movement or had a bilateral deficiency on the weight-bearing lunge forward lunge. The individual prior injury subjective component is scored on a 0-1 ordinal scale. A score of 1 indicates no prior injury whereas a score of 0 indicates prior injury. For personal concern of future injury, a score of 2 indicates no concern, a score of 1 indicates mild to moderate concern, and a score of 0 indicates significant concern for injury.

The weight bearing forward lunge test was performed in barefoot or stocking-foot (whichever is appropriate) conditions. Participants assumed a shoulder-width staggered stance position with two fingers touching the wall, as a balance aid only, and the tip of the forward great toe 12cm from the wall. The subject lunged forward attempting to keep the front heel on the ground. The participant received 2 points for bilateral patellae contacting the wall and the great toe positioned 12cm or greater away from the wall. One point was awarded for unilateral achievement and 0 points if the test was painful or the subject was unable to complete the test. The investigator measured the distance from the great toe to the wall in the event the subjects were unable to meet the standard. Measurement of weight bearing dorsiflexion has been found to be reliable for novice and expert testers.[4,21]

The modified deep squat was initiated with the participant standing barefoot and the shoulders abducted and elbows flexed to 90 degrees. With the toes facing directly forward, the subject attempted to squat low enough for the thighs to break parallel with the floor. 2 points were received for an upper torso that remained parallel with the tibia or vertical, arms in line with the torso, femur below horizontal, and the knees aligned over the feet. Failure to meet any of the criteria listed resulted in one point, and 0 points if the test was painful.

The closed kinetic chain upper extremity test (CKCUEST) required the subject to assume a push-up position with the shoes on. Males started in the push-up position and females began in the kneeling push-up position. With the back slightly inclined in relation to the floor and the hands 36 inches apart, the subject leaned over to touch one hand on the other and then returned the hand to the starting position. Tape marked the starting position and a towel was placed under the knees for comfort. This was repeated quickly and 2 points were awarded for 20 repetitions, 1 point for less than 20 repetitions, and 0 points awarded if the test was painful regardless of the number of repetitions completed. The CKCUEST has a high test-retest reliability and interrater reliability is excellent.[32,35] It is significantly correlated with both left and right side injuries. It has a sensitivity of 0.83, a specificity of 0.79, and odds ratio of 18.75 in determining a shoulder injury using a score of 21 touches.[31]

The forward step down with eyes closed began with the now shod subject standing on a standard 8-inch step with the feet approximately shoulder width apart. The subject held two hardcover textbooks, weighing approximately 15 pounds, at navel level with the eyes closed. The subject stepped down with one leg at a time while the investigator stood in front of the subject for safety. 2 points were awarded if the subject kept the eyes closed and there was no deviation of the lower extremities in the frontal plane. 1 point was awarded if the eyes opened, a loud foot landing, or any frontal plane deviation was noted. Finally, 0 points were awarded if the test was painful.

The stationary tuck jump involved the subject standing with feet shoulder width apart, arms at the side in an athletic crouched position. The subject initiated a jump with arms extended behind the subject and while swinging the arms forward the subject jumped vertically, pulled the knees up as high as possible and then attempted to land softly in the same position. This was repeated quickly three times such that each jump occurred immediately upon landing from the preceding jump. If the subject could perform 3 jumps with thighs at least oriented 45 degrees in the coronal axis, landing in the same position with a soft landing 2 points were awarded. 1 point was awarded if the subject did not meet the criteria, and 0 points awarded if the test was painful. The tuck jump assessment has been shown to be an easily performed test to identify high risk landing mechanics.[25,26]

The unilateral wall sit hold required the subject to stand with body weight evenly distributed between both feet, feet shoulder width apart, with the shoes on. The back was pressed against the wall with the hips and knees flexed to create an angle between the wall and thigh at 45 degrees. The arms hung vertically and then the subject lifted one foot such that it was 1-2 inches off the floor. The investigator started the stopwatch and then stopped at 30 seconds or when the athlete could not sustain the test position. 1 minute of rest was followed by testing of the contralateral limb. 2 points were awarded for maintaining the test position for 30 seconds bilateral. Only 1 point was awarded for holding less than 30 seconds on either extremity and 0 points awarded if the test was painful.

The Feagin hop test involved the subject standing directly on a line with the non-test lower extremity held in slight knee flexion with the shoes on. The subject performed a maximum effort vertical hop.. This was performed twice on each leg. Two points were awarded for landing in the same position with a soft landing and no frontal plane deviation bilateral. Only 1 point was awarded if the subject did not meet all criteria above and 0 points awarded if the test was painful.

Before participating in this research project, all investigators completed 2 hours of training during a mock performance performed 2 days prior to initial data collection. For each day, the research team set up 9 stations; one designated for check-in, seven stations designated for physical performance measures, and the last for check-out. The same co-investigator manned each station for each day of data collection while the primary investigator monitored each station for correct performance and subject questions. The investigators were all licensed physical therapists with 6 of the 7 therapists certified in orthopedics or sports physical therapy from the American Board of Physical Therapy Specialties. There was a combined experience of 74 years(mean 10.6 years).

Questionnaire

Participants completed a questionnaire to assess their history of previous injury and other descriptive information. The first question asked, “Have you experienced a prior injury that limited your participation in athletics or daily activity for more than seven days within the last 12 months?” Response categories were “yes” or “no”. 1 point was awarded for the answer no and 0 points awarded for answering yes. The follow-on question asked, “If you answered yes for question #1, please identify the following from your prior injury by circling the answer that best fits your injury.” “Was the injury on your left or right?” “The injured body part was the head, arm, leg, back, or chest/torso?” “The injury occurred during contact or non-contact sport?” Next, the subject’s personal concern for injury was asked with this question: “How would you describe your personal concern for sustaining a musculoskeletal injury within the next nine months?” Responses included, “no concern for injury, mild to moderate concern for injury, or significant concern for Injury.” 2 points were awarded for no concern for injury. 1 point was awarded for mild to moderate concern for injury and 0 points awarded for significant concern for injury. Age in years, height in inches, weight in pounds, and gender were recorded next. Finally, subjects were asked the following question, “How would you classify yourself?” Responses included, “Arab, Asian/Pacific Islander, Black, Caucasian/White, Hispanic, Multiracial, and Other.”

Documentation

All health related records were stored in three primary locations including the paper-based local athletic training record, and two automated medical documentation systems: the Cadet Illness and Injury Tracking System (CIITS), and the Armed Forces Health Longitudinal Technology Application (AHLTA). All medical encounters were reviewed initially by the principal investigator. In a separate meeting, the United States Military Academy Preparatory School (USMAPS) two certified athletic trainers and principal investigator collected all injury documentation occurring from August 2014 through May 2015. Similar to Garrison's study investigating injury prediction[14], injury was defined as an event that resulted in physical impact to the body during the academic school year, the injury required the subject to seek medical care from an athletic trainer, physician, or physical therapist, and the injury resulted in modification of activity for a minimum of 24 hours. The following details regarding each injury occurrence were recorded: contact or non-contact mechanism, traumatic or atraumatic, exact anatomic location(s), diagnosis, activity or sport mechanism of injury, and finally the number of lost duty days.

Data Analysis

MRST means scores were compared between injured and uninjured groups via the T-test. To determine if a threshold value emerged from the data, a receiver-operator characteristic (ROC) curve was generated. All potential MRST composite scores were evaluated to see if any score would be associated with the greatest degree of both sensitivity and specificity. Several elements of the data were analyzed including total MRST score, history of past injury, and a personal concern of injury. Odds ratios, sensitivity, specificity, and likelihood ratios were calculated for each of these conditions. To determine if the MRST could predict future injury, logistic regression models were performed. Predictor variables were determined by analyzing individual component scores on the MRST, the composite MRST score, past history of injury, and personal concern for injury. Data analysis was performed using R Core Team 2015 v 3.1.1. (R Foundation; Vienna, Austria).

RESULTS

One hundred thirty-three participants were included in the final data analysis. Eight participants were lost to follow-up because they left the academy for personal reasons. Mean age was 18.63 (±1.31), mass 81.04kg (±16.98), and height 177.46cm (±10.21). One hundred ten (83%) of the subjects were male. Forty-one percent of the subjects were self-reported Caucasian/white, 38% black, and 12% multiracial. Seventy preparatory cadets sustained an injury and sixty-three did not sustain an injury during the nine month 2014-2015 academic school year. The top 4 activities resulting in injury were: football (36%), basketball (11%), free time (11%), and track (10%). Injuries predominantly occurred at the knee (24%), hip (15%), and ankle (14%).

Figure 2. USMAPS Injuries By Sport

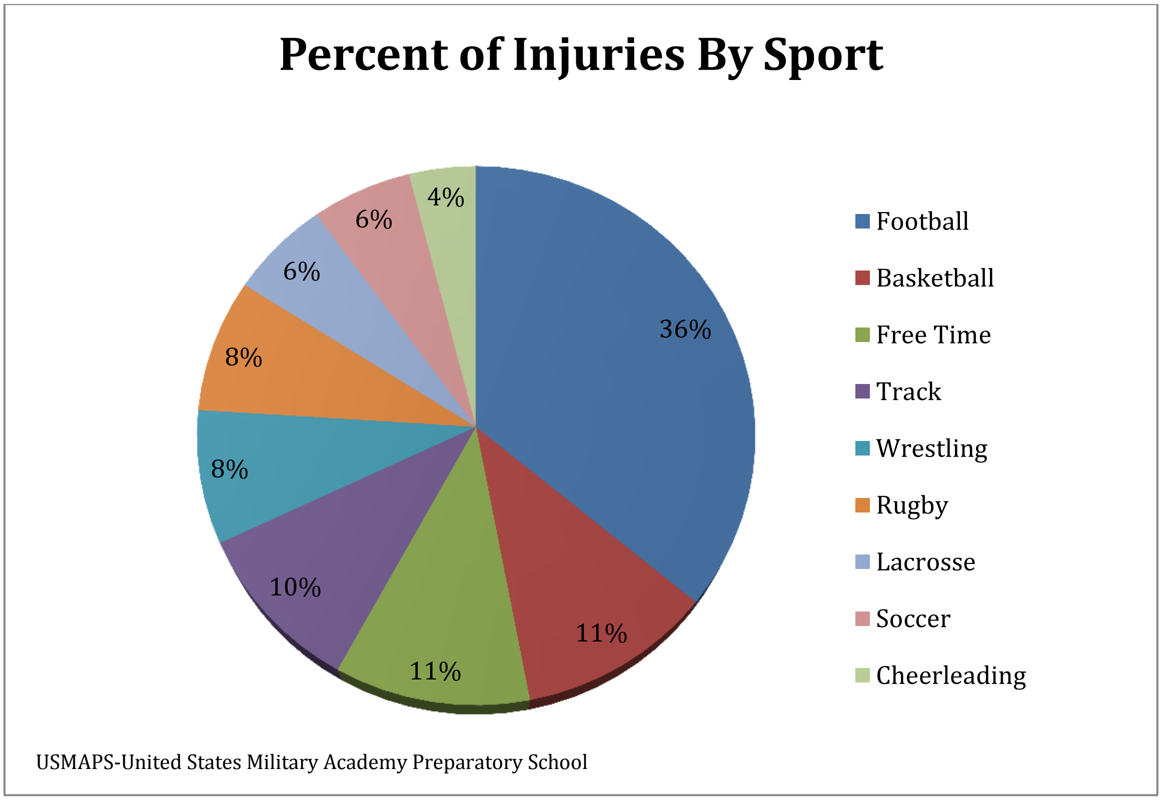
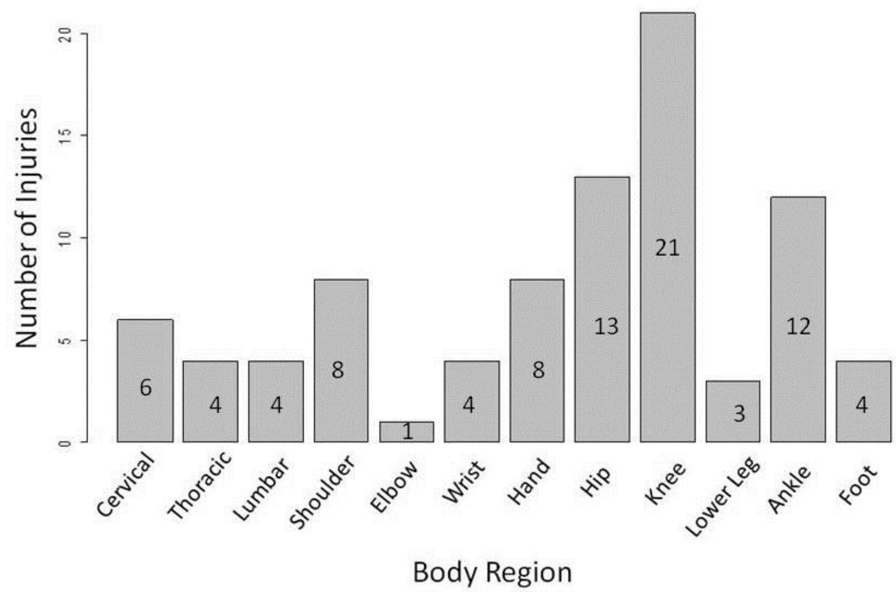


Figure 3. USMAPS Injuries By Body Region



USMAPS-United States Military Academy Preparatory School

The mean MRST composite score for the injured group was 10.83 and for the uninjured group 10.93. Comparing these means with an independent t-test resulted in no statistical significant difference between the two groups (p=.78), 95% confidence interval (-0.64, 0.85). No statistical difference was observed between composite MRST scores for overuse injury at 12.54 to the uninjured and acute injury groups at 12.64 (p=.85), with 95% confidence interval (-0.94, 1.13).

The impact of prior injury and personal concern for injury had on future injury was also investigated. Using the Pearson's Chi-Squared Test there was a significant association between those reporting a prior injury and those incurring a future injury (p=.04)No significant association was observed between those with a personal concern for future injury and those actually incurring a future injury (p=.13).

Sensitivity and specificity were calculated based on composite MRST score. With a score of ≤11, sensitivity was .30, specificity .73, positive likelihood ratio(+LR) 1.11, and negative likelihood ratio (-LR) .96. A score of ≤12 revealed a sensitivity of .50, specificity of .57, +LR 1.17, and –LR .89. The receiver operating characteristic area under the curve was .53 with 95% confidence interval (0.44, 0.63).

Table 1. USMAPS Pearson's Chi-Square Test for Self Reported Prior Injury and 9 Month Follow-Up Injury

	Uninjured	**Injured**	**P-value**	**df**	**95% CI**
Prior Injury	11	23	0.04	1	-0.34, -0.01
No Prior Injury	52	47			

Table 2. USMAPS Pearson's Chi-Square Test for Self Reported Concern For Injury and 9 Month Follow-Up Injury

	Uninjured	**Injured**	**P-value**	**df**	**95% CI**
Concern	2	1	0.13	2	-0.3, 0.04
Some Concern	21	37			
No Concern	40	32			

Table 3. Sensitivity and Specificity Calculations

	Sensitivity	Specificity	Positive Likelihood Ratio	Negative Likelihood Ratio
MRST ≤11	0.30	0.73	1.11	0.96
MRST ≤12	0.50	0.57	1.17	0.89
Previous History of Injury	0.33	0.83	1.88	0.81

Table 4. Data For The MRST With Different Cutoff Points

Cutoff Point	Sensitivity	Specificity
17	1	0
16	0.99	0.05
15	0.93	0.10
14	0.79	0.21
13	0.64	0.41
12	**0.50**	**0.57**
11	0.30	0.74
10	0.17	0.86
9	0.07	0.92
8	0.04	0.95

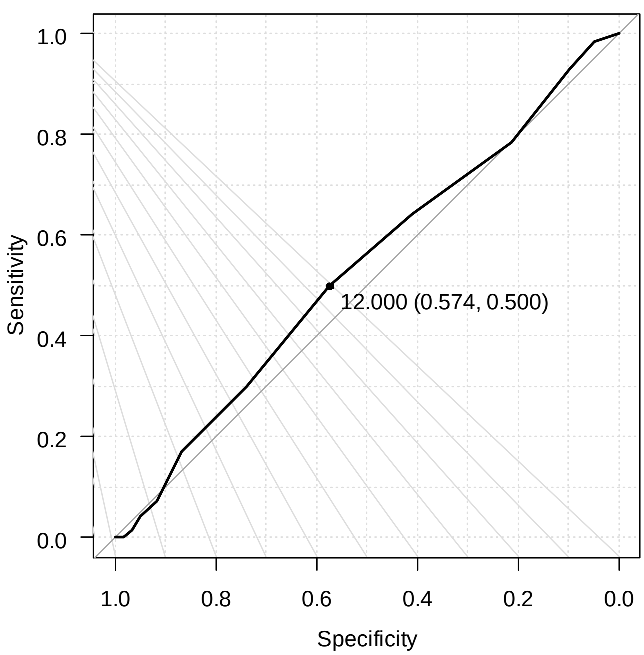
MRST-Musculoskeletal Readiness Screening Tool

Table 5. Receiver Operating Characteristics (ROC) Curve

Area	95% CI
0.53	0.44, 0.63

CI: Confidence Interval, Area: Area Under The Curve

Figure 4. Receiver Operating Characteristics (ROC) Curve For The Musculoskeletal Readiness Screening Tool (MRST) Scores at Different Cutoff Points



Odds ratios compared the predictive power of the MRST composite scores and prior injury. The odds ratio was 2.31 (1.02, 5.25) for prior injury. The odds ratios were 1.16 (0.55, 2.47) and 1.33 (0.67, 2.64) for a composite MRST score of less than 11 and 12, respectively.

Table 6. Odds Ratios and Confidence Intervals

	Odds Ratio	95% Confidence Interval
MRST ≤11	1.16	0.55, 2.47
MRST ≤12	1.33	0.67, 2.64
Previous History of Injury	2.31	1.02, 5.25

MRST-Musculoskeletal Readiness Screening Tool

Discussion

This is the first prospective screening study examining a large cohort of young, athletic participants with the recently proposed MRST. The results indicate that a cut-off score of 12 maximizes specificity and sensitivity. While individual components of the MRST have shown to be correlated with future injury, the combination of individual tests did not effectively predict injury in this cohort.

Multiple studies show that a history of previous injury is the strongest individual predictor of future injury.[17,18,21,38] This was consistent with the results of this study. The odds ratio of 2.31 (1.02, 5.25) for prior injury demonstrates that a preparatory cadet with a history of a prior injury in the previous 12 months has more than two times greater chance of injury than a preparatory cadet without a prior injury.

It is important to understand this population is unique and the results may not be generalizable to others. A typical week for this cohort involved daily physical training for 9 months, various athletic sport practices, and military marching with and without a rucksack. The combination and variety of these physical demands potentially increases their exposure to injury. Higher levels of physical fitness protect against injuries, but more physical training also causes higher injury rates.[28]

Careful attention was placed on ensuring injuries were documented in the USMAPS injury tracking system, athletic training records, and the electronic military health record. It is possible that injuries were over-reported compared to other studies secondary to the careful documentation by medical staff. Sensitivity and specificity were calculated based on MRST score. A USMA preparatory cadet that reported a previous injury had an 83% chance of sustaining an injury. The ROC curve analysis demonstrated that a composite score of 12 out of 17 points has the best balance between sensitivity and specificity for this screening tool in this population. Given the area under the curve, we can accurately predict future injury only 53% of the time, which was essentially no better than chance. The odds ratio of 1.16 (0.55, 2.47) and 1.33 (0.67, 2.64) for a composite MRST score of less than 11 and 12 respectively, demonstrates that a preparatory cadet with these scores has 16% and 33% increased chance of injury than a preparatory cadet with a higher score.

Musculoskeletal injuries represented the leading cause of medical care visits across the military.[28] Physical training and sports are the main cause of non-battle injuries, 56% a direct result of physical training. This is consistent with the injuries reported in this training environment with 53% resulting in injury. Similar to recent studies examining hospitalizations as a result of Air Force and Army injuries related to sports and physical training, basketball, football, and softball were the most common sports associated with injury.[22] This was similar to the results of this study with football, basketball, and free time ranking the three most common activities associated with injury. Also similar to Lauder and colleagues,[22] the top injuries directly involved the lower extremity with the knee being the most common site of injury.

Previous investigators have observed that causative psychological factors and the fear of re-injury influence return to play and injury risk.[1,36,37] However, in this current population we did not find fear of injury to be an injury predictor. Thus far individual tests have been positively associated with predicting injury. The FMS has shown to predict injury in various settings including the young athletic population similar to this one. Although the MRST did not predict injury in this population, the MRST may be useful in predicting injury outside of a basic cadet training environment. Various units in the military participate in physical activity regularly, without the daily sport activity frequently encountered in a preparatory school. Evaluating the predictive abilities of the MRST in other military units will help determine its utility in the military.

This study has some limitations which should be taken into consideration.. First, this study is descriptive in nature; Exposure to specific physical training was not controlled for nor was the exposure to specific sports. Also, hours spent with each sport were not accounted for. Understanding the exposure to training and the participants' prior fitness levels may help account for the amount of risk the subjects were exposed to and allow for a more accurate comparison of exposure to other studies. It is important to note this is not representative of the USMA population, but rather the USMAPS. Finally, although the investigators are all physical therapists, the reliability of the MRST in this configuration has not been reported, further limiting the application of the results.

The results of this study provide valuable information to clinicians. It is clear that a prior history of injury continues to be a strong risk factor for injury. Although the MRST did not predict injury, it still provided information on the incidence of injury, the sports most commonly associated with injury, and the incidence of injury according to body location in this select population.

CONCLUSION

This study contributes to the current research investigating functional movement and screening tools used to predict future injury. It also adds to the epidemiological research demonstrating lower extremity injuries and sports such as football and basketball account for the most injuries. Given that the only factor directly associated with injury in this study was reported previous injury, clinicians should continue to query athletes regarding their injury history. Future research should focus on evaluating the reliability, predictive and convergent validity of the MRST, or another screening tool, if it is to potentially be considered a viable option for injury prevention within the military.

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